My invention relates to electron multipliers, and more particularly to an electron discharge device wherein linear electron multiplication takes place to the end that an amplified output 5 may be secured of an electron input, the device being energized by self-generated alternating current.

Among the objects of my invention are: to provide a means and method for amplifying small electron currents; to provide a combined photocell, electric cathode, and electron multiplier; to provide a system wherein, in a single envelope linear electron multiplication takes place together with alternating current generation; to provide linear amplification of photo-emission; to provide a combined photo cell, electron multiplier, and driver within a single envelope, and utilizing at least certain electrodes in common; to provide a three-electrode photo cell wherein electron multiplication of the photo-emission is obtained with linear amplification; to provide a means and method of controlling the output of a photo cell; to provide a means and method of amplifying the output; to provide a simple and efficient method of energizing an electron multiplier with alternating current generated in the same envelope.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Figure 1 is a diagrammatic, sectional view of one form of tube structure embodying my invention, together with a circuit diagram showing operating connections.

Figure 2 is a similar view of a modification of my invention.

In my prior applications, for an Electron multiplying device, Serial No. 692,585, filed October 7, 1933, Patent No. 2,071,515, dated Feb. 23, 1937; and an Oscillation generator, Serial No. 733,837, filed July 5, 1934, Patent No. 2,071,516, dated Feb. 23, 1937, I have described electron multipliers and oscillators operating by the repeated impact of a cloud of electrons against a surface capable of emitting secondaries at a ratio greater than unity, and I have disclosed and claimed as one modification of the device, a diode structure. I have also pointed out in both of these cited applications that certain methods of treating surfaces for the production of secondaries at a ratio greater than unity leave the surface in a condition wherein photo-emission may also be obtained. In addition, I have pointed out that these multiplier structures may be utilized in two manners. First, as a linear electron multiplier wherein the electrodes are driven, or in other words, supplied with alternating potentials from an external source. In which case, linear outputs of initial input electrons may be obtained. I have further pointed out that it is possible to cause these devices to generate self oscillations when properly connected, and that I have shown in my latter instance the tubes usually operate at an equilibrium point where space charge tends to destroy linearity of output, when a controlled input is utilized. While it is possible, therefore, to build a multiplier wherein only two electrodes are utilized, and where the initial electrons are supplied to it, it is not practical to allow the device to self-oscillate and thus obtain an output which is a direct function of the input. Such a structure, however, would give a linear output provided the electrodes are driven from another source.

I have discovered that by the addition of only a single additional electrode, I am able to cause one part of the device to generate oscillations to energize another portion of the device to the end that the driven portion will give a linear response to initial input electrons.

In this present application I have described my structure basically comprising three electrodes with their appropriate circuits as being supplied with initial electrons liberated by the action of light, i.e., photo-emission; but I wish it to be distinctly understood that the same action can be obtained with the same electrode structure and circuit, irrespective of whether the initial electrons are liberated by the action of light or are liberated within operating space of the electrodes from other sources. In other words, my present device is capable not only of amplifying photo-emission, but also any emission whose component electrons are liberated or otherwise projected into the operating space of the device. Such modifications of my device are well within the knowledge of those skilled in the art, and, while I have shown in the preferred embodiment the device as described which answers the requirements very effectively, I do not desire to be confined to the precise details, either of construction or arrangement or mode of application, but aim in my claims to cover all
modifications which do not involve a departure from the spirit and scope of the invention as set forth in the appended claims.

Other broad aspects of my invention may be more fully understood by direct reference to the figures, which show two modifications, both according to the same principles.

In Figure 1, an envelope 1 is provided with a cylindrical cathode 2 perforated close to one end thereof with an aperture covered by a screen 4. Concentrically positioned within the cathode 2 are two adjacent cylindrical anodes, a photo cell anode 5 and an oscillator anode 7. These anodes are approximately the same size and shape, and each one co-operates with approximately one-half of the inner surface of the cathode. This inner surface is sensitized in this embodiment to perform a dual function; it must produce secondary electrons at a ratio greater than unity upon electron impact therewith, and it must also in this particular adaptation product photoelectrons under the influence of light. Fortunately, a caesium oxide surface will fulfill both of these requirements, and therefore we have chosen this material for the entire cathode of silver, oxidize the inner surface, and deposit metallic caesium thereon until a balance is reached where secondary emission and photo-emission are both good. While I have found that the two maxima do not coincide, they are sufficiently close so that if either one is checked the other will be within the proper operating range.

After the inner surface of the cathode has been sensitized the tube is exhausted, sealed, and connected in its operating circuit. The oscillator anode 6 is connected to the positive end of an oscillator source 1 through a resonant circuit 9. The cathode is grounded and the photo cell anode 5 is connected to the positive end of anode source 1 through a radio frequency choke 10 and a work circuit 11, diagrammatically represented in this case by a current indicator. A variable condenser 12 is bridged across the two anodes, as shown, the anode source 1 is connected to the oscillator anode 6 the electron multiplier comprising anode 6 and cathode 2 starts to operate as a multiplier oscillator. Electrons within the space bounded by anode 6 are accelerated away from and against cathode 2 at a frequency determined by resonant circuit 9, and at each impact with the cathode generate additional secondary electrons until the current generated builds up to an equilibrium value. There will be, therefore, a variation of potential across resonant circuit 9, and this potential is transmitted to anode 5 through the variable condenser 12; the amount of energizing potential reaching anode 5 depending, of course, upon the adjustment of the condenser 12.

In operation, as soon as the light, as represented by arrow 14, is directed into the interior of the cathode cylinder, this light illuminates the interior wall of the cathode adjacent photo cell anode 5. Photoelectrons are emitted which are, because of the driving potential on anode 5, accelerated away from and against the inner surface of cathode 2 adjacent anode 5, and are multiplied, the multiplied electrons eventually being collected by anode 5 as uni-directional pulses. Radio frequency choke 10 keeps radio frequency energy from passing through the work circuit, but the unidirectional pulses received by anode 5 pass readily through this choke and through the work circuit 11. Thus, for an extremely small light value, high output currents are obtained, and as the photo cell multiplier combination is driven the output will be linear, or substantially so, within a wide range. The frequency of self-oscilation generated by the device is, of course, determined by the resonant circuit 9 and may be, for example, between five and forty megacycles, depending on the number of secondary emission impacts desired in the photo cell end of the tube.

The two operating spaces within the device are separated by an insulating shield 15 positioned on one of the anodes, dividing the space and preventing electrons from crossing from one operating space into the other. It will be seen, therefore, that the system shown in Figure 1 has a single cathode and a double anode. However, an alternative construction is shown in Figure 2, and there is little to choose between the two. In this latter case, the cathode is divided into two parts, a photo cell cathode 16 and an oscillator cathode 17, whereas a single anode 19 extends co-axially with both cathodes and over substantially the entire extent thereof. In this case, the single anode is supplied with steady potential from anode source 1, and the oscillator cathode 17 is connected to the anode 19 through resonant circuit 9 grounded and blocking condenser 20. In this instance, the output is taken directly from the photo cell cathode 16 through radio frequency choke 10 and work circuit 11 to ground, and the multiplication control is performed by the variable condenser 12 connecting the two cathodes. Light enters the device through the photo cell cathode 16 and screen 4 in exactly the same manner as was described for Figure 1, and the operation is identical. There is little difference between the two embodiments shown except that under certain circumstances it is possible to sensitize the two cathodes differently in the embodiment shown in Figure 2 so that maximum photo-emission is obtained in the photo cell end, and maximum secondary emission obtained in the oscillator end. This is an advantage rather than a drawback inasmuch as the best photo-emitters are also good secondary emitters, although the converse is not always true.

As explained above, it will be within the knowledge of those skilled in the art to substitute an electron gun, a hot filament, or electrons liberated in any manner for the photo-emitting combination, and the use of the device as a multiplying photo cell is illustrative only, although, as a photo cell it obviously has a wide range of uses.

I claim:

1. An electron multiplier comprising a single envelope containing a pair of diode electron multiplier structures, external circuit means for operating one of said structures as an electron multiplier, external circuit means for operating the other of said structures as an electron multiplier oscillator, and means for connecting the oscillator output to energize said multiplier.

2. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons
within the operating space of said latter cathode and said anode.

3. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential and photoelectric cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode and said anode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons within the operating space of said latter cathode and said anode, both of said cathodes being at the same potential.

5. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode and said anode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons within the operating space of said latter cathode and said anode.

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